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REPORT DOCUMENTATION PAGE	Form Approved OMB No. 0704-0188

1. AGENCY USE ONLY (Leave blank)	2. REPORT DATE	3. REPORT TYPE AND DATES COVERED
	30 Jul 90	Final, 1 Jun 87 - 31 Dec 89

4. TITLE AND SUBTITLE	5. FUNDING NUMBERS
ONR Basic Research Program: Summary and Bibliographies	N00014-87-K-0346
6. AUTHOR(S) Muir, Thomas G. Donoghue, Beverly Emerson	
7. PERFORMING ORGANIZATION NAMES(S) AND ADDRESS(ES) Applied Research Laboratories The University of Texas at Austin P.O. Box 8029 Austin, Texas 78713-8029	8. PERFORMING ORGANIZATION REPORT NUMBER ARL-TR-90-24
8. SPONSORING/MONITORING AGENCY NAME(S) AND ADDRESS(ES) Office of the Chief of Naval Research Department of the Navy Arlington, Virginia 22217	10. SPONSORING/MONITORING AGENCY REPORT NUMBER
11. SUPPLEMENTARY NOTES	
12a. DISTRIBUTION/AVAILABILITY STATEMENT Approved for public release; distribution is unlimited.	12b. DISTRIBUTION CODE

13. ABSTRACT (Maximum 200 words)

Research conducted under the subject contract is surveyed from a bibliographical perspective based on an inventory of published research documents. This survey is intended to be useful in managerial evaluation of the funded research program.

14. SUBJECT TERMS	15. NUMBER OF PAGES
(See Reverse Side)	16. PRICE CODE

17. SECURITY CLASSIFICATION OF REPORT	18. SECURITY CLASSIFICATION OF THIS PAGE	19. SECURITY CLASSIFICATION OF ABSTRACT	20. LIMITATION OF ABSTRACT
UNCLASSIFIED	UNCLASSIFIED	UNCLASSIFIED	SAR

NSN 7540-01-280-5500

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Standard Form 298 (Rev. 2-89)
Prescribed by ANSI Std. 239-18
298-102

14. absorption
active sonar systems
Arctic
benchmark wedge
bispectral investigation
eigenvalue probability
GDEM HOP
Lorenz attractor
nearfield response
ocean acoustic database
polyspectral analysis
PVdF hydrophones
SAFARI model
seafloor profiling
signal processing
target strength
transducer fabrication
variational theory
acoustic imaging
airborne acoustics
active control processes
bispectral analysis
controlled vibrations
fluid-fluid interface
Hamilton's Principle
magnetoacoustic effect
noncollinear interaction
parametric array
polyspectral response
quadratic response
scattering of sound by sound
shallow water wedge
steepest-descent integration
three-dimensional wedge
underwater acoustics
wideband monopulse sonar
acoustic propagation models
acoustic scattering center model
bathymetry database
bubbly liquids
eigenray structure
focusing (Ham)
frequency dependent ray theory
Gaussian superposition model
Khokhlov-Zabolotskaya equation
parametric measurement
propagaiion modeling
ray model solutions
radio frequency propagation
shallow water waveguides
substructure-based parallel algorithm
time-bandwidth signals
ultrasonic proximity sensor

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1. INTRODUCTION

The subject contract was issued for the performance period 1 June 198⁻ to 31 December 1987, in response to ARL:UT proposal Ser P-1445, dated 5 December 1986,[1] this contract succeeded ONR Contract N00014-80-C-0490.[2] These contracts were funded out of the ONR discretionary block for support of ARL:UT, ARL:PSU, APL:UW, and MPL:SIO:UCSD in what is called the "ARL program". This block is administered by Dr. Marshall Orr and Mr. Marvin Blizard, ONR Code 1125OA. The subject contract was renewed and extended to include the performance period 1 January 1988 to 30 September 1988, in response to ARL:UT proposal Ser P-1458, dated 5 July 1988;[3] extended to include the performance period 1 October 1988 to 30 September 1989, in response to ARL:UT proposal Ser P-1480, dated 5 July 1988;[4] and extended to include the performance period 1 October 1989 to 31 December 1989, in response to ARL:UT proposal Ser P-1504, dated 15 September 1989.[5] This contract has been succeeded by ONR Grant N00014-90-J-1366, which was issued in response to ARL:UT proposal Ser P-1502, dated 17 August 1989,[6] and includes the performance period 1 October 1989 through 30 November 1990.

Two detailed annual reports[7,8] were issued on the subject contract for fiscal years 1988 and 1989. Since these annual reports were comprehensive in their survey of research accomplishments, the final report presented here is intended only to summarize and to offer bibliographical data on the documented results and achievements.

1.1 CONTRACTUAL INFORMATION

Figure 1.1 summarizes the ARL program at ARL:UT from FY87 to FY90. During FY88, $280,653 was allocated to the subject contract, which provided support for 13 research projects, involving 12 graduate students, three UT Austin faculty members, and one visiting scientist. In addition, support was provided for five high school graduates who did summer projects under ARL:UT's Defense Science and Engineering Apprenticeship Program.

During FY89, $133,000 was allocated, providing support for 11 research projects, involving 11 graduate students, nine faculty members, and five high school graduates.

The primary guideline for work conducted under the subject contract was to involve UT graduate students and faculty on research problems having naval relevance. These research problems involved underwater acoustics, signal processing, structural acoustics, physical acoustics (nonlinear and chaotic systems), and plasma physics (spark-induced sound). Through the graduate students, the access to faculty was far greater than is indicated by the numbers given in preceding paragraphs, which only include those faculty actually serving as dissertation and thesis advisors of graduate students. At ONR's request, the primary guidelines have changed for follow-on work, now in progress, to emphasize fewer research programs, that are somewhat larger and are concentrated in special focused areas. The resulting ARL program at ARL:UT for FY90 is summarized in Fig. 1.2.

Purpose:

- Access UT campus professors and apply their expertise to Naval research
- Support High School Apprenticeship Program (50/50 with IR&D)

Sponsor:

- Dr. Marshall Orr, ONR 1125OA
- Individual core area project officers

	FY87	FY88	FY89	FY90
$K	285.1	280.7	133.0	279.3
No. of Active Projects	10	13	11	4
No. of Students	10	12	11	5
No. of Faculty	8	11	9	3

Figure 1.1
ARL Program at ARL:UT

ARL:UT
AS-90-570
TGM - RFG
8-8-90 D37

1) Structural Acoustics (special focus)

2) Thermoacoustic Instability and Chaotic Systems

3) Spark Source Theory

4) Defense Science and Engineering Apprenticeship Program for high school graduates

- Tenth year; 63 students have completed program
- Introduction to DoD research and development
- Incentive to major in science and engineering
- Summer employment; specific project assignment

Figure 1.2
ARL Program at ARL:UT – FY90 Tasks

ARL:UT
AS-90-571
TGM - RFG
8-8-90 D37

2. RESEARCH RESULTS

The following is a summary, in bibliographical format, of the scientific documentation produced as the end product of the subject contract. We include work that may have begun under the preceding contract, but was either finished or reported during the subject contract.

2.1 ARCHIVAL PUBLICATIONS

Here we present the bibliographical data as well as the abstract of each paper that appeared in refereed journals. We also include publications that have been submitted, but are still in the journal editing process, which is sometimes quite lengthy.

1. Darvennes, C. M., and M. F. Hamilton (1990). "Scattering of Sound by Sound from Two Gaussian Beams," *J. Acoust. Soc. Am.* **87**(5), 1955-1964.

   The scattering of sound by sound from Gaussian beams that intersect at small angles is investigated theoretically with a quasilinear solution of the Khokhlov-Zabolotskaya nonlinear parabolic wave equation. The closed form solution, which is valid throughout the entire paraxial field, is a generalization of a result obtained previously for parametric receiving arrays [Hamilton et al., *J. Acoust. Soc. Am.* **82**, 311-318 (1987)]. Significant levels of scattered sum and difference frequency sound are shown to exist outside the nonlinear interaction region. An asymptotic formula reveals that sound is scattered in the approximate directions of $\mathbf{k}_1 \pm \mathbf{k}_2$, where $\mathbf{k}_j$ is the wave vector associated with the axis of jth primary beam. Computed propagation curves and beam patterns demonstrate the dependence of the scattered radiation on interaction angle, source separation, ratio of the primary frequencies, and source radii. Comparisons are made with the farfield results presented by Berntsen et al. [*J. Acoust. Soc. Am.* **86**, 1968-1983 (1989)], which are valid for arbitrary interaction angles, source separations, and amplitude distributions.

2. Hawkins, J. A., and A. Bedford (submitted to *J. Acoust. Soc. Am.*, June 1990), "Variational Models for a Bubbly Liquid with a Distribution of Bubble Sizes."

   Using Hamilton's principle, two models are derived for the acoustics of a bubbly liquid containing bubbles of different sizes. In the first model, we treat the bubbly liquid as a mixture of a liquid and several bubble "continua" consisting of bubbles of different sizes. In the second model, we treat the bubble liquid as a mixture of a liquid and a bubble continuum that has a specified continuous distribution of bubble sizes.

3. Henderson, T. L., and S. G. Lacker (1989). "Seafloor Profiling by a Wideband Sonar: Simulation, Frequency-Response Optimization, and Results of a Brief Sea Test," *IEEE J. Oceanic Eng.* **14**(1), 94-107.

An ahead-looking probe of some kind, optical or acoustic, is critical when one is attempting seafloor exploration from a mobile platform. A single-frequency, split-aperture sonar system can be used for this purpose, but a wideband monopulse sonar offers many advantages. It computes a running estimate of the vertical direction cosine of the source of the echo, and can thus reveal the positions of multiple wave scatterers as long as their echoes can still be time resolved. Theoretical studies of its performance have been made previously, but were directly applicable only to extremely simple seafloor geometries. A new time-domain digital simulation that largely circumvents this limitation has been developed. The simulation also provides a means for testing the theory and optimizing system parameters. Our reverberation model does not account for some features of acoustic backscattering such as diffraction, but it is believed to be adequate for the investigation of most signal processing aspects of the sonar system. The theory of the simulation is developed and several examples are presented and discussed. In addition, some preliminary results are presented from a sea test that used the air-sea interface as a surrogate seafloor.

4. Lacker, S. G., and T. L. Henderson (1990). "Wideband Monopulse Sonar Performance: Cylindrical Target Simulation Using an Acoustic Scattering Center Model," *IEEE J. Oceanic Eng.* **15**(1), 32-43.

An ahead-looking sonar can be used in the underwater environment for obstacle avoidance and observation of seafloor features. Single frequency, split-aperture sonar systems are useful in these applications, but a wideband monopulse sonar is preferable because of its performance characteristics. Previous theoretical studies of this type of sonar have been limited to very simple seafloor geometries and have scarcely addressed the response to objects in the ocean volume. A time-domain simulation which lends itself to the study of complex ocean environments, including complex seafloor shapes and suspended objects, has been developed. This simulation is used to study the response of a monopulse sonar to the presence of rigid cylinders near the seafloor. An acoustic scattering center model is developed to represent the cylinders, and several examples are presented and discussed.

5. Sample, J. D. (1988). "Gaussian Models for Complex Sound Sources in the Paraxial Region," *J. Acoust. Soc. Am.* **84**(6), 2252-2261.

A Gaussian superposition model is proposed for complex, directive sound sources to simplify the calculation of their paraxial sound fields. The source field is approximated by a superposition of many Gaussian beams, each calculated using one of two paraxial (or parabolic) approximations. Both paraxial approximations are examined in detail with regard to the minimum assumptions required and the range of validity. In particular, a phase error in the commonly used paraxial approximation for a Gaussian beam is examined to ensure that it will not result in amplitude errors in the superposition model. Finally, the model is used to calculate the sound field of a circular piston source, and the results obtained are compared with the sound field calculated by more traditional methods.

6. Westwood, E. K. (1989). "Complex Ray Methods for Acoustic Interaction at a Fluid-Fluid Interface," *J. Acoust. Soc. Am.* **85**(5), 1872-1884.

   The development of a systematic method for finding the reflected and transmitted fields due to a point source in the presence of a plane, penetrable interface is presented. This approach is based on the classical method of steepest descent, but the plane-wave reflection and transmission coefficients are allowed to influence the location of the saddle points and their steepest descent paths. As a consequence, saddle points are, in general, complex, and complicated processes, such as the reflected lateral wave field and the evanescent field in the bottom, are incorporated in the saddle point formulation. The geometric interpretation of the saddle point criterion is derived in terms of eigenrays and their characteristics, from which expressions are obtained for the ray displacement upon reflection and transmission. Summaries of the eigenray structure of the reflected and transmitted fields are given for low-frequency situations.

7. Westwood, E. K. (1989). "Ray Methods for Flat and Sloping Shallow-Water Waveguides," *J. Acoust. Soc. Am.* **85**(5), 1885-1894.

   A ray method for finding the acoustic field due to a point source in the presence of a plane, penetrable interface is extended to two simple models for shallow-water ocean environments: the flat, isovelocity waveguide (the Pekeris model) and the sloping, isovelocity waveguide (the penetrable wedge). In both cases, the sound speed in the bottom is assumed larger than that in the water. The total field is expressed as a sum of ray fields, each of which takes the form of a plane wave integral. The integrals are solved using the method of steepest descent, where the plane wave reflection and transmission coefficients are allowed to influence the location of the saddle points. For a Pekeris waveguide in which three modes are trapped, agreement between the ray model and the SAFARI model is nearly perfect at all ranges, while the discrete normal mode solution is in error when a mode is near cutoff. The ray model is accurate even when the water depth is half of the acoustic wavelength. For the penetrable wedge problem, the plane wave integral for the ray field is developed, and the origin of the multiple lateral wave fields is examined. Excellent agreement between the ray model and a two-way coupled mode model is demonstrated. Examples of the eigenray structure in both the flat and sloping waveguides are given.

8. Westwood, E. K. (1990). "Ray Model Solutions to the Benchmark Wedge Problems," *J. Acoust. Soc. Am.* **87**(4), 1539-1545.

   A ray method is used to calculate the acoustic field in the shallow-water, penetrable wedge problems proposed as benchmarks by the Acoustical Society of America. Agreement is excellent between the ray solution and the two-way coupled-mode solution.

The ray approach not only constitutes an independent method for comparison with other models, but also provides an intuitive picture of the propagation in terms of eigenrays. An analysis of the eigenray information provided by the ray model reveals that the effects of backscatter are totally insignificant for the penetrable wedge problems considered. The computation time required on a Cyber 180-830 to calculate the field at a single point varies from 5 s near the source to 60 s near the apex of the wedge. The calculation of the field at 400 points along a horizontal line requires less than 10 min.

2.2 NON-ARCHIVAL PUBLICATION

Bibliographical data and abstracts for a paper that appeared in a non-refereed publication, such as the proceedings of symposia, etc., are presented here, along with the dates, location, sponsor, and special topic of the publication.

1. Bennighof, J. K., and M. C. Sciascia (1989). "A Substructure-Based Parallel Algorithm for Large Structure Eigenvalue Probability," ONR/NUSC/WPI Symposium on the Solutions of Super Large Problems in Computational Mechanics, 18-19 October 1988, Mystic, Connecticut (Plenum Press, New York).

   A parallel algorithm is presented for solving large structure eigenvalue problems. The computation is parallelized on the basis of a division of the structure into substructures. The algorithm resembles the basic subspace iteration algorithm, but the reduced subspace is augmented to include previous iterates for eigenvectors that have not yet converged, and substructure eigenvectors, which are computed by substructure processors when they might otherwise be idle. Including previous iterates results in convergence approximating that of the Lanczos method, and including substructure eigenvectors enhances convergence further. An advantage of the present approach over the Lanczos method is that the reduced subspace does not grow as large, because basis vectors that do not enhance convergence significantly are automatically removed from the subspace, decreasing storage requirements. A numerical example demonstrates the method and shows the results that can be expected.

2.3 DISSERTATIONS AND THESES

Bibliographical and biographical information on these fiducial academic documents is presented here in a format designed to illustrate the research topics, the student graduates, their professors, and ARL:UT co-researchers, as well as their relationships within the academic and naval research and service communities. It should be remembered that each of the graduates is a U.S. citizen, and each is a potential candidate for a leadership role in the conduct of future naval research and development.

Dissertations

1. Foreman, T. L. (Physics, 1987). A Frequency Dependent Ray Theory, under T. A. Griffy (UT and ARL:UT); worked with R. Pitre (ARL:UT); employed at Naval Research Laboratory upon completion of Ph.D., presently employed at Mitre Corporation, McLean, Virginia.

2. Sample, J. (Physics, 1988). Nearfield Response of a Parametric Receiving Array, under C. W. Horton, Sr., and T. A. Griffy (UT); worked with M. F. Hamilton, D. T. Blackstock, and A. W. Nolle (UT), and N. Chotiros, R. Culbertson, J. Huckabay, G. Barnard, R. Rolleigh, J. N. Tjøtta, and S. Tjøtta (ARL:UT); graduate of U.S. Naval Academy; attended nuclear power school, prototype training and submarine school; served one submarine tour and completed two deployments; employed at ARL:UT upon completion of Ph.D.; seeking academic appointment.

3. Westwood, E. K. (Electrical Engineering, 1988). Acoustic Propagation Modeling in Shallow Water Using Ray Theory, under H. Ling and M. F. Hamilton (UT) and T. A. Griffy (UT and ARL:UT); worked with H. Hobaek, J. N. Tjøtta, S. Tjøtta, R. A. Koch, and S. K. Mitchell (ARL:UT); employed at ARL:UT upon completion of Ph.D.

Theses

1. Bailey, D. E. (Physics, 1987). The Magnetoacoustic Effect in Copper Using Ultrasonic Surface Waves, under J. D. Gavenda (UT); employed at Texas Instruments, Dallas, Texas, upon completion of M.A.

2. Bartels, K. (Electrical Engineering, 1988). Feasibility of Very Large Time-Bandwidth Signals in Active Sonar Systems, under E. L. Hixson and J. C. Thompson (UT) and T. L. Henderson (UT and ARL:UT); entered Ph.D. program at UT in Electrical Engineering upon completion of M.S.

3. Lacker, S. G. (Electrical Engineering, 1988). Wideband Monopulse Sonar Performance: Cylindrical Target Simulation Using an Acoustic Scattering Center Model, under T. L. Henderson (UT and ARL:UT), E. L. Hixson (UT); worked with R. Culbertson, J. M. Huckabay, C. M. Loeffler, N. P. Chotiros, R. Rolleigh, and A. Holly (ARL:UT); employed at ARL:UT upon completion of M.S.

4. O'Donnell, R. B. (Electrical Engineering, 1989). Bispectral Investigation of Active Control Processes, under G. R. Wilson (ARL:UT) and R. O. Stearman (UT); worked with W. E. Brown (ARL:UT) and E. Powers (UT); graduate of U.S. Naval Academy; attended nuclear power school and completed three and one-half year tour on USS JAMES K. POLK, qualified in submarines and as Engineer Officer for nuclear-powered submarines, two-year tour with Naval Intelligence; employed at Bolt Beranek & Neuman, Washington, D.C.

2.4 DISSERTATIONS AND THESES IN PROGRESS

These projects were initiated under the subject contract and are listed below. Due to the aforementioned change in primary guidelines, many of these have now been reassigned to other funding sources, including ARL:UT Independent Research and Development (IR&D) funds.

Dissertations

1. Hawkins, J. A. (Aerospace Engineering and Engineering Mechanics), under A. M. Bedford (UT); working with J. A. TenCate and J. N. Tjøtta (ARL:UT), and D. T. Blackstock (UT).

2. LeMond, J. (Physics), under Dr. W. D. McCormick (UT); working with T. A. Griffy (UT).

3. TenCate, J. A. (Mechanical Engineering), under M. F. Hamilton (UT); working with D. T. Blackstock (UT), and J. A. Hawkins and J. N. Tjøtta (ARL:UT).

Theses

1. Cook, J. A. (Physics), under A. M. Gleeson (UT); working with R. L. Rogers (ARL:UT).

2. Fox, D. J. (Mechanical Engineering), under R. O. Stearman (UT); working with G. R. Wilson, W. E. Brown, J. H. Sheehan, and J. L. Lamb (ARL:UT).

2.5 PAPERS PRESENTED AT MEETINGS

Titles, authors, and meeting data are listed below. Almost all of these presentations will end up as archival papers such as those listed above. The presentation of scientific papers at meetings is a give-and-take process that enables the authors to receive criticism, comments, and an exchange of information that sharpens the work perspective and its ultimate relevance, prior to submission as an archival contribution.

1. Bennighof, J. K., and M. C. Sciascia. "A Substructure-Based Parallel Algorithm for Large Structure Eigenvalue Probability," ONR/NUSC/WPI Symposium on the Solution of Super Large Problems in Computational Mechanics, Mystic, Connecticut, 18-19 October 1988.

2. Darvennes, C. M., and M. F. Hamilton. "Scattering of Sound by Sound from Two Gaussian Beams," 115th Meeting of Acoust. Soc. Am., Seattle, Washington, 16-20 May 1988.

3. Darvennes, C. M., M. F. Hamilton, J. N. Tjøtta, and S. Tjøtta. "Effects of Absorption on the Scattering of Sound by Sound," 117th Meeting of Acoust. Soc. Am., Syracuse, New York, 22-26 May 1989.

4. Darvennes, C. M., M. F. Hamilton, J. N. Tjøtta, and S. Tjøtta. "Effects of Focusing on the Scattering of Sound by Sound," 118th Meeting of Acoust. Soc. Am., St. Louis, Missouri, 27 November - 1 December 1989.

5. Darvennes, C. M., M. F. Hamilton, and J. N. Tjøtta. "Parametric Reception near a Reflection Surface," 119th Meeting of Acoust. Soc. Am., State College, Pennsylvania, 21-25 May 1990.

6. Hawkins, J. A., and A. M. Bedford. "The Application of Hamilton's Principle to a Bubbly Liquid," 118th Meeting of Acoust. Soc. Am., St. Louis, Missouri, 27 November - 1 December 1989.

7. Hawkins, J. A., and A. M. Bedford. "Variational Theory for a Partially Saturated Porous Medium with a Distribution of Bubble Sizes," 33rd Meeting of The Society for Natural Philosophy, Pittsburgh, Pennsylvania, October 1989.

8. Lee, Y-S, and M. F. Hamilton. "A Parametric Array for Use as an Ultrasonic Proximity Sensor in Air," 116th Meeting of Acoust. Soc. Am., Honolulu, Hawaii, 14-18 November 1988.

9. Lind, S. J., and M. F. Hamilton. "Noncollinear Interaction of a Tone with Noise," 114th Meeting of Acoust. Soc. Am., Miami, Florida, 16-20 November 1987.

10. Sample, J. D. "Parametric Measurement of Sound Source Directivity: Effect of the Source Nearfield," 116th Meeting of Acoust. Soc. Am., Honolulu, Hawaii, 14-18 November 1988.

11. Yavari, B., and A. M. Bedford. "Computation of the Biot Coefficients," 114th Meeting of Acoust. Soc. Am., Miami, Florida, 16-20 November 1987.

12. Westwood, E. K. "The Modeling of a Shallow-Water Wedge Using Complex Rays and Steepest-Descent Integration," 115th Meeting of Acoust. Soc. Am., Seattle, Washington, 16-20 May 1988.

13. Westwood, E. K. "Complex Ray Methods for Flat and Sloping Waveguides," 116th Meeting of Acoust. Soc. Am., Seattle, Washington, 16-20 May 1988.

14. Westwood, E. K. "Propagation Modeling in a Three-Dimensional Wedge Using Ray Theory," 117th Meeting of Acoust. Soc. Am., Syracuse, New York, 22-26 May 1989.

2.6 ARL:UT REPORTS

In addition to the archival papers, dissertations, theses, and other highly valued scientific documents cited above, there is a very real and important need for the publication of a variety of reports that are useful in the conduct of work. These include translations and analyses of foreign scientific literature, internal reports surveying technology, etc. These are listed below.

In order to facilitate distribution, theses and dissertations are normally reissued as laboratory reports, as indicated by the report numbers cited in Section 2.3 above. Copies of all of these reports are available upon request to the ARL:UT Library, limited only by certain foreign distribution restrictions cited in the subject contract.

1. Bartels, Keith A. (1989). "Feasibility of Very Large Time-Bandwidth Signals in Active Sonar Systems," Applied Research Laboratories Technical Report No. 89-11 (ARL-TR-89-11), Applied Research Laboratories, The University of Texas at Austin.

2. Brown, W. Eugene, and Richard B. O'Donnell (1990, in progress). "Polyspectral Response of Controlled Vibrations," Technical Report, Applied Research Laboratories, The University of Texas at Austin.

3. Foreman, Terry L. (1988). "A Frequency Dependent Ray Theory," Applied Research Laboratories Technical Report No. 88-17 (ARL-TR-88-17), Applied Research Laboratories, The University of Texas at Austin.

4. Lacker, Stephen G. (1988). "Wideband Monopulse Sonar Performance: Cylindrical Target Simulation Using an Acoustic Scattering Center Model," Applied Research Laboratories Technical Report No. 88-61 (ARL-TR-88-61), Applied Research Laboratories, The University of Texas at Austin.

5. O'Donnell, Richard B. (1990, in progress). "Quadratic Response from the Forced Vibration of a Thin Cylindrical Shell Due to Geometric Imperfections," Technical Report, Applied Research Laboratories, The University of Texas at Austin.

6. Sample, John D. (1988). "Nearfield Response of a Parametric Receiving Array," Applied Research Laboratories Technical Report No. 88-62 (ARL-TR-88-62), Applied Research Laboratories, The University of Texas at Austin.

7. Westwood, Evan K. (1989). "Acoustic Propagation Modeling in Shallow Water Using Ray Theory," Applied Research Laboratories Technical Report No. 89-6 (ARL-TR-89-6), Applied Research Laboratories, The University of Texas at Austin.

8. Westwood, Evan K. (1988). "Ray Model Solutions to the Benchmark Wedge Problems," Applied Research Laboratories Technical Paper No. 88-7 (ARL-TP-88-7), Applied Research Laboratories, The University of Texas at Austin.

2.7 DoD SCIENCE AND ENGINEERING APPRENTICESHIP REPORTS

The purpose of the apprenticeship program is to provide outstanding recent high school graduates with hands-on experience in a stimulating research environment and encourage them to pursue careers in the science and engineering disciplines, particularly in those areas related to the needs of the Department of Defense. Students were selected for this program on the basis of their academic records, scholastic aptitude test results, applications, and references from their teachers. Each student was assigned to a research project to be performed under the supervision of a research staff member at ARL:UT. At the end of the apprenticeship in mid-August, students gave oral presentations with visuals for the laboratory's directors and prepared short technical papers summarizing their projects' results. The annual reports[9,10] included technical papers by the following student authors, whose abstracts are also included.

1988 Participants

Michael Berry	Computer Modeling of Sound Propagation in the Atmosphere
Jerry Carter	Bispectral Analysis of the Lorenz Attractor
Top Changwatchai	Acoustic Imaging with Ambient Noise: A Simulation
Mary Dahlquist	Radio Frequency Propagation in Arctic Regions
Eric Howard	GDEM HOP and Bathymetry
Matthew Kaplan	Software and Data Transfer for the NASA/JSC Relative Positioning Project

Tina Yang	Modeling Sound Passage through Ocean and Ocean Bottom
	Guide to Using the Alliant and Microvax with Sample Program: 3D Beam Pattern

1989 Participants

Gatlin, Coley	Airborne Acoustics
Joy, Jeffrey	Ocean Acoustic Database Access through a PC
Nguyen, Giao	Polyspectral Analysis of a Feedback Controlled Oscillator
Nguyen, Khue	Simulation by Domestic Pigs of Acoustic Properties of Human Drowning Victims
Opiela, John	Experimental Production of PVdF Hydrophones

Abstracts of Apprenticeship Reports

1. Berry, Michael. "Computer Modeling of Sound Propagation in the Atmosphere," August 1988.

   The following report briefly describes an investigation which was conducted from June 6, 1988 to August 19, 1988 at Applied Research Laboratories, The University of Texas at Austin. This investigation was undertaken to determine the possibility of developing an acoustic alternative to electromagnetic surveillance techniques foı use in the atmosphere. A ray tracing program, called MEDUSA, was applied to this study. An environmental model was created and examinations of all facets of this model were tested. These examinations primarily included the production of propagation loss data for several source-receiver pairs at varying altitudes over a 100 km by 11 km atmospheric environment. The source frequency was 100 Hz. Analysis was also performed on a 69 km altitude, 100 km long model. In addition, acoustic reciprocity was studied.

2. Carter, Jerry. "Bispectral Analysis of the Lorenz Attractor," August 1988.

   The results of power and bispectral analysis of the Lorenz attractor are discussed. The bispectrum is a method of examining the interaction between nonlinearly coupled frequencies. Also mentioned is the effect of state and parameter changes on the bispectrum.

3. Changwatchai, Top. "Acoustic Imaging with Ambient Noise: A Simulation," August 1988.

To model using ambient noise in acoustic imaging, I simulated sound with light because the optical equipment was available and I could control the conditions more easily. I first took pictures using a pinhole aperture and a bright flash to see what resolution and image clarity I could obtain. I then took pictures using laser light for illumination because of its coherence and narrow frequency range. The laser represented an acoustic transmitter, and I wanted to see whether it provided enough illumination to image objects. Finally, I simulated basic ocean conditions and took pictures using a laser to simulate active acoustic imaging and a flash to simulate ambient noise from surface waves.

4. Dahlquist, Mary. "Radio Frequency Propagation in Arctic Regions," August 1988.

This report focuses on describing the atmospheric medium through which electromagnetic energy travels, so that an understanding of how the energy is distributed can ultimately be gained through use of a propagation model. From the calculations done in this report, it was concluded that, given raw or modified temperature and vapor pressure data, it is possible to locate refractive atmospheric conditions in the marginal ice zone (MIZ) using IREPS classifications. IREPS is an atmospheric propagation model which was developed at the Naval Ocean Systems Center.

5. Gatlin, Coley. "Airborne Acoustics," August 1989.

The following report briefly describes a data collection project conducted at Applied Research Laboratories, The University of Texas at Austin (ARL:UT). The purpose of the project was to further the knowledge of airborne acoustics in an effort to develop an acoustic alternative to electromagnetic surveillance techniques. Data was collected by a recording system and analyzed to determine unique characteristics of the sounds produced by aircraft.

6. Howard, Eric. "GDEM HOP and Bathymetry Data Base for the Apple Macintosh Computer," August 1988.

The purpose of this report is to explain some of the background, define specifications, and present a basic description of the logic behind writing a program for the Apple Macintosh computer that could access the GDEM HOP and bathymetry data files and display the information in a variety of formats useful to the staff at ARL:UT.

7. Joy, Jeffrey. "Ocean Acoustic Database Access through a PC," August 1989.

A brief background and a project status report on a Hypercard-based application for retrieving ocean acoustic data from the Alliant mainframe computer are presented.

8. Kaplan, Matthew. "Software and Data Transfer for the NASA/JSC Relative Positioning Project," August 1988.

This report details the transfer of software and data from a CYBER to the Microvax computer for the National Aeronautics and Space Administration/Johnson Space Center (NASA/JSC) relative positioning project. This project had three objectives. The first was to upgrade the software using a new format and restructure it from lab analysis software to operational software. The second was to make modifications in the software so that it could be compiled on the Vax. The last objective was to transfer these programs, their associated subroutines, and the related database from the CYBER to the Vax.

9. Nguyen, Giao. "Polyspectral Analysis of a Feedback Controlled Oscillator," August 1989.

This project provides an understanding of the effects of controls on different oscillators (linear or nonlinear) under different types of controls (discrete time or continuous) with either one driving force or two driving forces by looking at the power spectrum plots and the bispectrum plots.

10. Nguyen, Khue. "Simulation by Domestic Pigs of Acoustic Properties of Human Drowning Victims," August 1989.

The objective of this project is to study the acoustic characteristics of a person in the water in an attempt to find a better method of locating human drowning victims. Dead pigs were used to simulate human corpses because their lungs appear to be physiologically very similar to human lung tissue; alveoli in the lungs appear to be the dominant target strength mechanism. Basic linear measuring techniques for different frequencies were used along with newer methods of nonlinear parametric measurement. The target strength with the parametric source was higher than with the linear source, implicating nonlinearities.

11. Opiela, John. "Experimental Production of PVdF Hydrophones," August 1989.

Polyvinylidene fluoride (PVdF) promises to be the ideal material for making a particular type of directional hydrophone. The steps in transducer fabrication included preparing the PVdF and brass, laminating with polyurethane, and potting. Then tank room tests, air bubble tests, and electrical contact tests were performed. PVdF meets the necessary standards, and it is very easy to use. This research has turned up possible solutions for small problems inherent in the production of PVdF transducers, and laid some fears to rest.

12. Yang, Tina. "Modeling Sound Passage through Ocean and Ocean Bottom," August 1988.

This report documents the process of modeling sound propagation through the ocean and the ocean bottom with special emphasis on the effects of varying bottom parameter . It includes a brief explanation of ocean paths and cross-correlation and an analysis of the correlograms. The model Ctrax2/300, located on the Alliant, allows for bottom inputs. A manual for running the model, "Ctrax Modeling," supplements the paper.

13. Yang, Tina. "Ctrax Modeling," August 1988.

This manual gives a step-by-step instruction of running ctrax2 and ctrax300 on the Alliant to generate gray intensity plots on the Vax. Ctrax300 is a version of ctrax2, modified by Hans Baade. It changes the dimensions of the range array allocation from 1000 to 300.

2.8 ONR SITE VISIT

On 5-6 September 1989, an ONR-appointed review committee visited ARL:UT and heard presentations on projects funded by the subject contract. These presentations were assembled in hard copy[11] and distributed to the participants. The review committee consisted of

Dr. Marshall Orr	ONR 1125OA	Chairman
Dr. Phillip B. Abraham	NRL/ONR	Reviewer
Dr. Chris de Moustier	MPL/Scripps	Reviewer
Dr. Robert W. Farwell	NORDA	Reviewer
Mr. John C. Harlett	APL/UW	Reviewer
Dr. Richard Stern	ARL/PSU	Reviewer
Mr. Steve Wolf	ONR	Reviewer

Dr. Orr prepared a written critique from the committee's observations that was submitted to ARL:UT for consideration. In this critique, Dr. Orr expanded the mission of the discretionary block program to include utilization of the funds as "seed money" to initiate new 6.1 research that might transition into other ONR core research programs. A verbal response was presented to Dr. Orr during a visit by T. Muir to ONR in March 1990. Although there were some differences of opinion, it was felt that the review and critique process were beneficial to both ONR and ARL:UT.

2.9 CITATION RECORD

According to the Science Citation Index,[12] nine professors and ARL:UT principal investigators as well as two ARL:UT students were cited a total of 139 times as prime references in the archival publications of the world during the period of the subject contract. The vast majority of these citations involved work directly sponsored by the subject contract.

3. SUMMARY AND CONCLUSION

A large inventory of research projects has been surveyed with a view toward identifying and summarizing the work done. Bibliographical data were provided so that the documented results on all of these projects can be accessed, and quality assessments can be made.

Most of the research efforts were small but unique projects involving individual efforts. These range from summer research tasks done by high school graduates to Ph.D. dissertations.

In general, the research results, which are well documented in the archival literature and in other literature, are considered to be an excellent and worthy justification for the expenditure of funds under this program.

REFERENCES

1. ARL:UT Proposal Ser P-1445, dated 5 December 1986, from Dr. Loyd Hampton, ARL:UT Director, to Mr. Robert L. Sternberg, ONR Code 1125OA, for $285,087 for the performance period 1 June 1987 - 31 December 1987.

2. ONR Contract N00014-80-C-0490, for the performance period 1 July 1980 - 30 September 1987, with total funding of $2,233,076 divided into eight increments.

3. ARL:UT Proposal Ser P-1458, dated 22 July 1987, from Dr. Loyd Hampton, ARL:UT Director, to Dr. Robert L. Sternberg, ONR Code 1125OA, extending performance period to 1 January - 30 September 1988, at a total estimated cost of $282,670.

4. ARL:UT Proposal Ser P-1480, dated 5 July 1988, from Dr. Thomas Griffy, ARL:UT Coordinator of Basic Research and Educational Programs, to Dr. Marshall Orr, ONR Code 1125OA, extending performance period to 1 October 1988 - 30 September 1989, revising description of work, and increasing total estimated cost and amount allotted by $133,000.

5. ARL:UT Proposal Ser P-1504, dated 15 September 1989, from Dr. Thomas G. Muir, ARL:UT Coordinator of Basic Research and Educational Programs, to Dr. Marshall Orr, Code 1125OA, for the performance period 1 October - 31 December 1989.

6. ARL:UT Proposal Ser P-1502, dated 17 August 1989, from Dr. Thomas G. Muir, ARL:UT Coordinator of Basic Research and Educational Programs, to Dr. Marshall Orr, ONR Code 1125OA, for $279,300 for the performance period 1 October 1989 - 30 November 1990.

7. "Annual Report for General Research Program, Contract N00014-87-K-0346, 1 July 1987 - 30 June 1988," Applied Research Laboratories Technical Letter No. DO-88-3 (ARL-TL-DO-88-3), Applied Research Laboratories, The University of Texas at Austin.

8. "Annual Report, ONR Contract N00014-87-K-0346, 1 July 1988 - 30 June 1989," Applied Research Laboratories Technical Letter No. DO-89-1 (ARL-TL-DO-89-1), Applied Research Laboratories, The University of Texas at Austin.

9. Griffy, Thomas A., ed. "The Department of Defense Science and Engineering Apprenticeship Program for High School Students, Summer Program, 1988," Applied Research Laboratories Technical Report No. 88-63 (ARL-TR-88-63), Applied Research Laboratories, The University of Texas at Austin.

10. Donoghue, Beverly Emerson, ed. "The Department of Defense Science and Engineering Apprenticeship Program for High School Students, Summer Program, 1989," Applied Research Laboratories Technical Report No. 89-41 (ARL-TR-89-41), Applied Research Laboratories, The University of Texas at Austin.

11. Office of Naval Research Biannual Site Visit at the Applied Research Laboratories, ONR Contract N00014-87-K-0346, 5-6 September 1989, Austin, Texas.

12. Science Citation Index, 1987, 1988, and 1989. Institute for Scientific Information, Philadelphia.

30 July 1990

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